Claims

What is claimed is:

1. A method of algorithmically simulating the transportation of particles through a medium, comprising the steps:

a) establishing a set of initial particle and environmental conditions;
b) creating a computational grid system of voxels from a physical object or system;
c) establishing a plurality of ray sets of particle distributions with a computational algorithm;
d) using ray sets and appropriate integration kernel to determine transport multipliers;
e) initiating the simulated transportation of particles by applying a plurality of discrete particle distributions within voxel interaction tallies and/or upon voxel tally surfaces;
f) applying the transport multipliers for transporting discrete particle tallies from the first plurality of voxels to a second plurality of voxels;
g) continuing the particle tallies in voxels as the ray sets of particle distributions sequentially transport through the grid system of voxels until a predetermined limit is attained;
h) compiling the particle interaction tallies from within computer memory locations and applying the interaction model to determine scattering, state and accumulated interactions over a time epoch or generation;
i) repeating steps (f-h) until interaction reaction rates and/or generational eigenvalue substantially converge; and
j) computationally producing an output indicative of the simulated particle transport.

2. A method of algorithmically simulating the transportation of particles through a medium, comprising:

a) establishing a set of initial particle and environmental conditions;
b) creating a computational grid system of voxels from a physical object or system;

c) establishing a plurality of ray sets of particle distributions with a computational algorithm;

d) using ray sets and appropriate integration kernel to determine transport multipliers;

e) initiating the simulated transportation of particles by applying a plurality of discrete particle distributions within voxel interaction tallies and/or upon voxel tally surfaces;

f) applying the transport multipliers for transporting discrete particle tallies from the first plurality of voxels to a second plurality of voxels;

g) compiling the particle interaction tallies from within computer memory locations and applying the interaction model to determine scattering, state and accumulated interactions over a time epoch or generation;

h) repeating steps (f-h) until interaction reaction rates and/or generational eigenvalue substantially converge; and

i) computationally producing an output indicative of the simulated particle transport

3. The method of claim 1 or 2, wherein the first voxel tally location associated with a set of multipliers is zeroed prior to undertaking step (g).

4. The method of claim 1 or 2, wherein the algorithmic computation for establishing a plurality of ray sets of particle distributions is performed using Monte Carlo techniques.

5. The method of claim 1 or 2, further comprising a plurality of discrete phase space variables used to model nuclear radiation transport.

6. The method of claim 1 or 2, further comprising a plurality of discrete phase space variables used to model electromagnetic particle transport.

7. The method of claim 6, wherein said electromagnetic particle transport

comprises infrared waves, optical waves, UV waves, radio waves or a combination thereof.

8. The method of claim 1 or 2, further comprising a plurality of discrete phase space variables used to model radioactive heat transfer.

9. A method of linking computer memory locations representing discrete particle tallies for the purpose of computing particle transport, comprising:

(a) assigning discrete particle tallies to voxel volumes, surfaces and function coefficients;

(b) assigning near exact multipliers representing a fraction of particles transported from a reference discrete particle tally to neighboring discrete particle tally locations with a plurality of appropriate discrete phase state variables;

(c) providing orderly specification of pointers to neighboring discrete particle tally locations related to transport multipliers from a reference tally location; and

(d) sweeping through a system of reference particle tallies and corresponding multipliers to transport discrete particles to neighboring voxel volumes, surfaces and function coefficients.

10. The method of claim 9 wherein said plurality of discrete phase space/state variables are used to model nuclear radiation transport.

11. The method of claim 9 wherein said plurality of discrete phase space/state variables are used to model electromagnetic particle transport.

12. The method of claim 11 wherein said electromagnetic particle transport comprises infrared waves, optical waves, UV waves, radio waves or a combination thereof.

13. The method of claim 9 wherein said plurality of discrete phase space/state variables are used to model radiative heat transfer.

14. The method of claim 9 wherein said plurality of discrete phase space/state variables are used to model sound waves.

15. A method of specifying geometric particle pathways using ray sets comprising one or more unique paths traversing a local system of neighboring voxels relative to a reference voxel volume or surface, said ray sets comprising:

(a) a unique descriptor of the ray set traversal path through a system of voxels;

(b) a specification linking ray sets emanating from a local voxel group to ray sets of adjacent local voxel groups;

(c) one or more representative rays of varying length traversing a consistent local system of neighboring voxels relative to a reference voxel volume or surface;

(d) a fraction of particles traversing particular rays relative to a specified emergent particle distribution; and

(e) lengths associated with rays within each traversed voxel.

16. A method of computing exact or near exact multipliers representing a fraction of particles transported from a reference discrete particle tally to neighboring discrete particle tally locations of appropriate discrete phase state, comprising:

(a) specifying a material composition within voxels;

(b) specifying a local voxel group within a general system;

(c) employing appropriate integration kernels representing particle attenuation within voxels due to particle-material interactions;

(d) creating ray sets comprising one or more unique paths traversing a local system of neighboring voxels relative to a reference voxel volume or surface; and

(e) applying integral kernel with ray set data to obtain unique multipliers representing aggregate transport of reference discrete particles to neighboring discrete particle voxel volumes, local voxel group surfaces and function coefficients.

17. The method of claim 16 further comprising a plurality of discrete phase space variables used to model nuclear radiation transport.

18. The method of claim 16 further comprising a plurality of discrete phase space variables used to model electromagnetic particle transport.

19. The method of claim 18 wherein said electromagnetic particle transport comprises infrared waves, optical waves, UV waves, radio waves or a combination thereof.

20. The method of claim 16 further comprising a plurality of discrete phase space variables used to model radiative heat transfer.

21. The method of claim 16 further comprising a plurality of discrete phase space variables used to model sound waves.

22. A method of computing particle transport, comprising:

(a) constructing a grid system of voxels representing a physical system;

(b) constructing transport multipliers using a technique for specifying geometric particle pathways using ray sets comprising one or more unique paths traversing a local system of neighboring voxels relative to a reference voxel volume or surface;

(c) creating initial conditions for computing particle transport;

(d) employing a technique for linking computer memory locations representing discrete particle tallies in order to transport particles in a sweep of computer memory applying transport multipliers to determine particle transport to function coefficients, surface and volume discrete particle tally locations through an impulsive sweep;

(e) computing particle interaction using an interaction model and resulting accumulated particle collision tallies to voxel volumes;

(f) terminating particle transport based on convergence criteria; and

(g) storing results.

23. The method of claim 22 further comprising a plurality of discrete phase space

variables used to model nuclear radiation transport.

24. The method of claim 22 further comprising a plurality of discrete phase space variables used to model electromagnetic particle transport.

25. The method of claim 24 wherein said electromagnetic particle transport comprises infrared waves, optical waves, UV waves, radio waves or a combination thereof.

26. The method of claim 22 further comprising a plurality of discrete phase space variables used to model radiative heat transfer.

27. The method of claim 22 further comprising a plurality of discrete phase space variables used to model sound waves.

28. The method of claim 23 used for medical therapeutic radiation treatment planning.

29. The method of claim 23 used in Intensity Modulated Radiation Therapy three-dimensional treatment planning

30. The method of claim 15 further comprising pre-computation of ray sets using Monte Carlo methods.

31. The method of claim 30 used for a regular geometric grid system.

32. The method of claim 15 further comprising specifying ray set pathways using hash encoded data describing the ray pathway through a voxel system.

33. The method of claim 15 further comprising specifying ray set pathways using a binary tree technique.

34. The method of claim 16 further comprising pre-computation of ray sets using Monte Carlo methods; and

use of memory reference hash pointers associating discrete particle memory in hash tables for assignment with discrete particle multipliers.

35. The method of claim 16 further comprising:

(a) associating subsurfaces and volumes for reference voxels;

(b) determining an initial particle weight for a fraction of discrete particles represented by the subsurface;

(c) using extended ray end points for determining adjacent LVG surface transport; and

(d) employing a system for determining ray sets based on start and end points, and associating said ray sets with reference discrete particles as well as creating ray set phase tally bins for particles emanating from LVG surfaces.

36. The method of claim 35 used for an irregular geometric grid system.

37. The method of claim 35 further comprising computing angular ray weights for volume emanating discrete particles from voxel volume particle source and interaction tallies.

38. The method of claim 22 further comprising incorporating an optimization module to determine optimal particle distribution, comprising:

(a) determining design optimization characteristics from transport computation output; and

(b) determining initial particle distribution for trial optimization.

39. A method of computing particle interactions within voxels, comprising:

(a) computing collision probabilities within voxel volumes;

(b) computing physical parameters associated with interaction; and

(c) computing function coefficients, volume or surface discrete particle tally distributions from interactions.

40. The method of claim 22 further comprising using distance moments to differentiate surface and volume emanating particle distributions.

41. The method of claim 22 used to compute an Interaction Model.

42. The method of claim 41 further comprising:

(a) using a finer grained Interaction Model to represent sub-volume interactions;

(b) using surface initial particle distributions to determine Interaction Model response; and

(c) using voids to permit proper ray set assignment dependent on applicable distance moments used to differentiate surface and volume emanating particle distributions.

43. The method of claim 42 wherein said finer grained Interaction Model is configured by computing particle interactions within voxels, comprising:

(a) computing collision probabilities within voxel volumes;

(b) computing physical parameters associated with interaction;

(c) computing volume or surface discrete particle tally distributions from interactions; and

(d) computing function coefficients representing angular distribution for high order particle scatter modeling.

44. The method of claim 16 further comprising a direct analytical solution of infinite ray interaction and transport integrals over a geometric system and a plurality of state variables, comprising:

(a) using a numerical or an analytical solution, and assuming constant discrete particle distribution over a discrete phase space; and/or

(b) accounting for appropriate angular distribution over the angular discrete phase space interval.

45. The method of claim 44 wherein one of said state variables comprises a solid angle for the first collision interaction moment.

46. The method of claim 9 further comprising extending neighboring discrete particle tally multipliers from reference tallies to all discrete particles in the system with consistent discrete phase space values.

47. The method of claim 15 further comprising extending neighboring discrete particle tally multipliers from reference tallies to all discrete particles in the system with consistent discrete phase space values.

48. The method of claim 9 further comprising direct wiring of particle tallies in an analogue computer system or an analogue digital hybrid.

49. The method of claim 16 further comprising using a pattern matching algorithm to speed computational processing of transport multipliers.

50. The method of claim 35 further comprising using a pattern matching algorithm to speed computational processing of transport multipliers.

51. The method of claim 41 further comprising explicit modeling of representative ray external beams entering a system, comprising:

(a) representative ray modeling of particles streaming into the system;

(b) using the Interaction Model to create an initial scattered radiation source; and

(c) using function coefficients to generate initial scattered radiation source distributions.

52. The method of claim 15 further comprising using a Monte Carlo method to compute pure geometric properties.

53. The method of claim 16 further comprising using alternative integration kernels for modeling particle transport in a software application.

54. The method of claim 15 further comprising using a Monte Carlo pre-calculation method to establish upper and lower bounds for ray set geometric properties in which an integration kernel is explicitly applied.

55. The method of claim 16 further comprising using a Monte Carlo pre-calculation method to establish upper and lower bounds for ray set geometric properties in which said integration kernels are explicitly applied.

56. The method of claim 39 wherein a collision probability method is used to form the core of an Interaction Model, said model capable of being modified to permit an impulsive initial value nature.

57. The method of claim 9 wherein particle transport solutions within specific time epochs are used to model transient systems.

58. The method of claim 22 wherein particle transport solutions within specific time epochs are used to model transient systems.

59. The method of claim 22 further comprising using an absolute system boundary convergence related to initial impulse.

60. The method of claim 59 used for non-fissile, non-time Eigenvalue problems.

61. The method of claim 23 further comprising using fission parameters within

the Interaction Model and system generational Eigenvalue.

62. The method of claim 23 further comprising using fission parameters within the Interaction Model and system generational Eigenvalue, and using generational moments within said Interaction Model.

63. The method of claim 23 further comprising using a function coefficients deposition method to spatially map surface or subsurface tally distributions in both an angular and spatial sense.

64. The method of claim 23 further comprising using a function coefficients deposition method to act as a data compression tool for LVG boundaries.

65. A method of accumulating ray tracing results to a multiplier field comprising the iterative steps of:

(a) selecting points upon a surface or within a volume;

(b) determining weight associated with a ray;

(c) perform a ray tracing from the selected point through the first voxel;

(d) identifying a pointer associated with terminal(s) of said voxel;

(e) determining the number of particles that are attenuated within that voxel;

(f) relating said pointer to multiplier(s) associated with a terminal of the attenuated particle in said voxel;

(g) using weight associated with ray, attenuation within voxel, and weight(s) associated with terminal(s) to add result to identified multiplier(s);

(h) continuing steps (d-g) until all terminal pointers appropriate for the ray within the voxel are identified and processed;

(i) reducing the number of particles continuing from the voxel;

(j) continuing to adjacent voxels, identifying pointers and accumulating multipliers (steps d-h) until a problem edge or a terminal surface is reached;

(k) identifying a pointer associated with a terminal on said surface;

(l) using weight associated with ray, attenuated particle fraction and weight(s) associated with terminal(s) to add result to multiplier(s) associated with pointers; and

(m) continuing steps (k-m) until all terminals appropriate for the ray are processed.